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INFLUENCE OF BODY COMPOSITION ON THE PREVALENCE OF POSTURAL DEFORMITIES IN 11 TO 13 YEAR OLD BLACK SOUTH AFRICAN CHILDREN IN THE NORTH WEST PROVINCE

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ABSTRACT

The aim of this study is to investigate the influence of body composition on the prevalence of postural deformities among Black South African children aged 11 to 13 years in selected schools in the Potchefstroom area in the North West Province. The sample (n = 168) consisted of 47 eleven year olds, 58 twelve year olds and 63 thirteen year old school children. Of the total number of students examined (168), 79 were boys, and 89 were girls. Anthropometric (BMI and percentage body fat) and body posture measurements were performed. A posture grid and the New York Posture test were used for all postural assessments. In boys, Spearman Rank Order Correlations demonstrated a statistical significant ($p<0.05$) association between protruding abdomen and BMI, and also for the association of winged scapulae and protruding abdomen with percentage body fat. A large practical significant difference ($d\approx0.8$) in BMI and percentage body fat was demonstrated between the different categories of winged scapulae and lordosis. In girls, Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between BMI and percentage body fat with winged scapulae, protruding abdomen and flat feet. A large practical significant difference ($d\approx0.8$) in BMI was demonstrated between the different categories of winged scapulae and flat feet and also in percentage body fat with regards to the different categories of flat feet. In summary the findings suggest that, winged scapulae and lordosis in boys, and flat feet in girls, are the postural deformities with the strongest association with BMI and percentage body fat. This study illustrates the need for a further investigation of more profound studies investigating factors such as BMI and percentage body fat.

Key words: Postural deformities; BMI; Fat%; Body composition; South Africa.

INTRODUCTION

Good posture is considered to be a measure of good musculoskeletal health (Banfield, 2000; McEvoy & Grimmer, 2005). Bad posture can alter the joint load distribution and the loading on these joints that are not normally aligned can lead to articular cartilage degeneration and can as a result lead to more serous postural deformities (Riegger-Krugh & Keysor, 1996; Norris, 2000).

The proportion of overweight and obese children is increasing at an alarming rate worldwide, both in developed and developing countries (Belizzi & Dietz, 1999; Fernàndez *et al*., 2003; Laitinen *et al*., 2005; Evers *et al*., 2007). Excessive weight increases loading on the spine and pressure on the discs and other structures of the back, and as result serious back problems may occur (Segell, 1998; Yip *et al*., 2001). According to Segell (1998), a high ratio of muscle to body fat ensures adequate support for the spine. Studies have reported an association between low back pain and weight (Fairbank *et al*., 1984; Mellin, 1987; Grimmer & Williams, 2000). However, other studies reported no association (Merriam *et al*., 1983; Pope *et al*., 1985; Biering-Sorensen & Thomsen, 1986; Kovacs *et al*., 2003).

Countries in economic transition from underdeveloped to developed, such as South Africa, are particularly affected and have an increasing prevalence of obesity across all economic levels and age groups. Food intake in rural areas is mostly unbalanced or inadequate and chronic malnutrition and undernutrition has been suggested as a contributory factor to elevated rates of obesity, because of the observed association between stunting in childhood and obesity in adults (Popkin *et al*., 1996; Sawaya *et al*., 1998).

It is clear that obesity is increasing at an alarming rate, and if there is a close association between obesity or overweight and postural deformities, the current trends of obesity appear to be cumbersome. Research examining the possible association between postural deformities and body composition is lacking. The aim of this study is to investigate the influence of body composition on the prevalence of postural deformities in 11 to 13 year old Black South African children in the North West Province.

MATERIALS AND METHODS

Participants

The age group selected was based on the idea that early recognition could lead to preventive measures for more serious conditions. In this age group most children are undergoing puberty and during this time children can develop postural problems. As most children are still growing until age 18 to 21, enough time is left to implement corrective treatment. Parental consent was obtained from all participants before participating in the study. Ethical approval was obtained from the Ethics Committee of the North-West University (Project number 05K13).

The schools were selected purposefully, because learners/pupils attending these schools are from living areas where the lowest income per household could be expected. Many people in these communities live in informal housing and some even without water supply and electricity. A letter was sent to three schools in the Potchefstroom area, explaining the importance and purpose of the study and to find out if any of these schools were interested in participating in this study. All three schools gave permission to conduct the study at their schools. Black South African children aged 11 to 13 years from these three primary schools in the Potchefstroom area in the North West Province participated in this study. The sample (n = 168) consisted of 47 eleven year olds, 58 twelve year olds and 63 thirteen year old children. Of the total number of students examined (168), 79 were boys, and 89 were girls.

Data Collection Procedures

The first stage of the measurement procedure was conducted with the children separated into groups according to school grade and gender. The measurements and examinations were completed over a one-month period during scheduled appointment hours within a private class setting. Measurement procedure was explained to children in detail to reduce any uncertainties and anxiety. With help from assistants, the participants completed a questionnaire. The questionnaire included personal details namely, age, gender, language, handedness and contact numbers. Thereafter, the anthropometric measurements and postural evaluation were assessed. To ensure complete reliability of the study the researcher did all the postural evaluations and the same assistants (trained postgraduate Biokinetics students) were used for all the measurements.

Anthropometric Measurements

Measurements were taken according to the standard procedures of the International Society for the Advancement of Kinanthropometry (ISAK) methods (ISAK, 2001). The following measurements were taken:

Stature

Maximum stature was measured to the nearest 0.1 cm with a stadiometer with the child standing upright and the head in the Frankfort plane.

Body mass

The children wore hospital gowns and underwear while their body mass was measured to the nearest 0.1 kg on an electronic scale (Krupps). The scale was calibrated at the beginning of the study with a 20 kg standard calibration weight. Using stature and body mass measurements, BMI was calculated (ACSM, 2006).

Skinfolds

The triceps and subscapular skinfolds were measured in duplicate to the nearest 0.2mm with a Harpenden® skinfold caliper with a constant pressure of 10 g/mm^2 (Cambridge Scientific Intruments, Cambridge, MA) and the two values averaged. Sites on the right side of the body were measured by trained postgraduate Biokinetics students. Percentage Body Fat was determined using a 2-site skinfold measurement (Triceps and Subscapular) (Slaughter *et al*., 1988).

Postural Evaluation

The New York Posture Test (Sherrill, 1993; Bloomfield *et al*., 1994; Davis *et al*., 1995; Reedco Inc. 2001; Magee, 2002; Pankey *et al*., 2004) and a "see-through posture grid" (Davis *et al*., 1995; Arnheim & Prentice, 2000; Kendall *et al*., 2005) were used for evaluation and identification of possible deformities. The "posture grid" comprises 12.5cm "big blocks", which is further subdivided into 2.5cm "small blocks". The vertical and horizontal strings are attached onto a frame. The vertical lines are at right angles to the horizontal lines. A plumb line is dropped from the top to bottom of the frame. These lines provide reference points for ascertaining the correct alignment of body parts (Davis *et al*., 1995; Arnheim & Prentice, 2000; Kendall *et al*., 2005). Each test item is scored on a 5-3-1 basis. The score is based on the criteria and drawings located on the score sheet (5 = normal; 3 = slightly abnormal; 1 = abnormal). The participants were examined from a lateral, posterior and anterior view. The participants stepped down into powdered white chalk and then onto a black board to check for flat feet. The "Adam's test" (forward bending test) was used for further scoliosis evaluation in order to confirm the scoliosis score in the New York Posture Test. To reduce the degree of subjectivity the following criteria are provided by the New York Posture Test (Reedco Inc. 2001) to score uneven shoulders: 5 (0 – 2 degrees); 3 (2.1 – 4 degrees); 1 (> 4 degrees).

The most superior-lateral edge of the acromions was marked with a pencil. Degree of lateral asymmetry are measured by counting the amount of blocks the one shoulder is lower than the other one. The examiner stood 4m from the posture grid. Using a goniometer, the amount of degrees for each block was measured beforehand. Subjects with a broader chest (greater bi-acromial width) will exhibit a greater angle of asymmetry. To account for these differences three bi-acromial widths were used. A subject will either be 2, 3 or 4 "large blocks" wide, which will be 25, 37.5 and 50 cm respectively.

The following mathematical calculation was used to determine the reliability of the goniometer measurements: E.g. acromion height difference of "1 block" (2.5 cm) and a bi-acromial width of "3 large blocks" (37.5 cm), where *t* = difference in acromion height and *a* = bi-acromial width (Taylor & Myburgh, 1987).

$$Tan\theta = \frac{t}{a}$$
$$= \frac{2.5}{37.5}$$
$$\theta = 4 \text{ degrees}$$

This mathematical measurement was compared to all goniometer measurements. The goniometer measurements correlated well with the mathematical measurements, and thus constitute a reliable method of measurement.

Statistical Analysis

Spearman Rank Order Correlations (r_S) were used to determine whether there was a statistical association ($p < 0.05$) between BMI and percentage body fat with prevalence of postural deformities. Instead of only reporting descriptive statistics in this case, effect sizes were determined. Practical significance can be understood as a large enough difference to have an effect in practice (Ellis & Steyn, 2003). Correlation is in itself an effect size or measure of the strength of association between two interval scale variables (Steyn, 2006). Cohen (1988) gives the following guidelines for the interpretation of the effect size in the current case: small effect: $|r_S| \approx 0.1$, medium effect: $|r_S| \approx 0.3$. large effect: $|r_S| \approx 0.5$. It is considered that data with $|r_S| \approx 0.5$ is practical significant, since it is the result of a difference having a large effect and $|r_S| \approx 0.3$ as a visible difference but not yet practical significant (Ellis & Steyn, 2003). As a further investigation into these associations, the difference in mean BMI and percentage body fat was also determined for the different categories of postural deformities. Effect size for the difference between means was used to determine practical significance (Ellis & Steyn, 2003). Where $|\bar{x}_1 - \bar{x}_2|$ is the difference between the means, $\bar{x}_1$ and $\bar{x}_2$, without taking the sign into consideration and $s_{\max}$ is the maximum of s_1 and s_2, the sample standard deviations. Cohen (1988) gives the following guidelines for the interpretation of the effect size in the current case:

(a) small effect: $d \approx 0.2$, (b) medium effect: $d \approx 0.5$ and (c) large effect: $d \approx 0.8$.

It is considered that data with $d \approx 0.8$ is practically significant, since it is the result of a difference having a large effect and $d \approx 0.5$ as a visible difference but not yet practical significant (Ellis & Steyn, 2003).

RESULTS

No practical significant association between age and the prevalence of deformities were found and thus the data of different age groups were grouped together to simplify comparisons and increase the power of the analysis. The effect of BMI and percentage body fat on the prevalence of postural deformities will be discussed separately. The prevalence rates for postural deformities for boys and girls are tabulated below (table 1).

TABLE 1: **THE PERCENTAGE PREVALENCE RATES OF POSTURAL DEFORMITIES FOR BOYS (N = 79) AND GIRLS (89).**

	Abnormal		**Slightly abnormal**		**Normal**	
Postural Deformity	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Lordosis	86	74	10	21	4	4
Winged Scapulae	57	63	38	31	5	6
Protruding abdomen	57	52	30	43	13	6
Kyphosis	22	47	66	45	13	8
Pronated feet	20	9	49	48	30	43
Flat feet	6	9	34	31	59	60
Uneven shoulders	10	8	13	16	77	76
Scoliosis	0	0	5	7	95	93

Effect of BMI on the prevalence rate of postural deformities

Boys with abnormal winged scapulae and lordosis (figure 1) demonstrated to have in practice a lower BMI (large effect, d≈0.8) than those who are normal. For uneven shoulders, boys in the abnormal category have a visibly lower BMI (medium effect, d≈0.5) than normal ones. For protruding abdomen and pronated feet, boys in the abnormal category have a visibly higher BMI (medium effect, d≈0.5) than normal ones. For flat feet, boys in the slightly abnormal category have a visibly higher BMI (medium effect, d≈0.5) than normal ones. Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between BMI and the prevalence of protruding abdomen ($r_s \approx 0.3$), where boys with a higher BMI showed a significantly higher prevalence rate for this deformity.

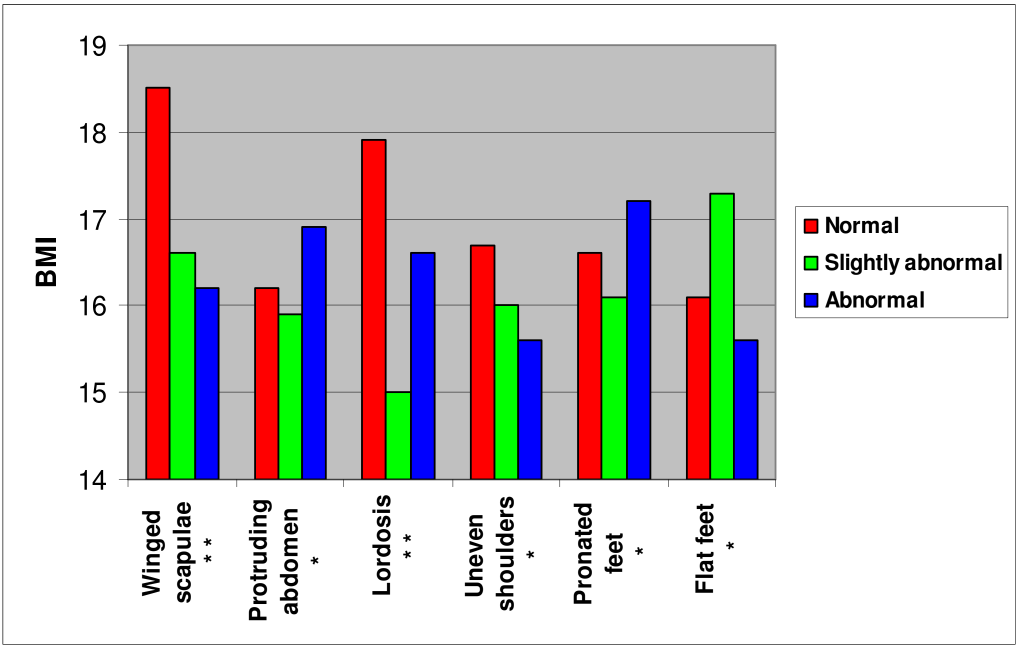

FIGURE 1: **THE EFFECT OF BMI ON THE PREVALENCE RATE OF POSTURAL DEFORMITIES IN 11 TO 13 YEAR OLD BLACK SOUTH AFRICAN BOYS (* * LARGE AND * MEDIUM PRACTICAL SIGNIFICANCE) (N = 79).**

For winged scapulae, girls in the abnormal category (figure 2) have a visibly lower BMI (medium effect, d≈0.5) than normal ones. For protruding abdomen and pronated feet, girls in the abnormal category have a visibly higher BMI (medium effect, d≈0.5) than normal ones. Girls with abnormal flat feet demonstrated to have in practice a higher BMI (large effect, d≈0.8) than those who are normal. Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between BMI and the prevalence of winged scapulae ($r_s \approx 0.3$), protruding abdomen ($r_s \approx 0.3$) and flat feet ($r_s \approx 0.3$). Girls with a higher BMI showed a significantly higher prevalence rate for protruding abdomen and flat feet, where girls with a lower BMI showed a significantly higher prevalence rate for winged scapulae.

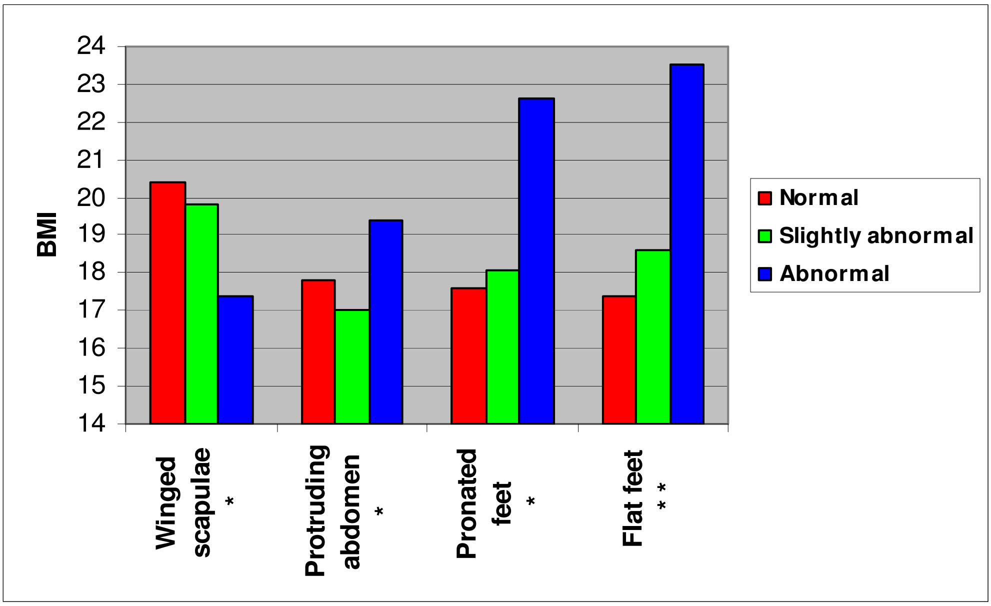

FIGURE 2: **THE EFFECT OF BMI ON THE PREVALENCE RATE OF POSTURAL DEFORMITIES IN 11 TO 13 YEAR OLD BLACK SOUTH AFRICAN GIRLS (* * LARGE AND * MEDIUM PRACTICAL SIGNIFICANCE) (N = 89).**

Effect of percentage body fat on the prevalence rate of postural deformities

Boys with abnormal winged scapulae and slightly abnormal lordosis (figure 3) demonstrated to have in practice a lower percentage body fat (large effect, d≈0.8) than those who are normal. Boys with abnormal uneven shoulders demonstrated to have a visibly lower percentage body fat (medium effect, d≈0.5). For protruding abdomen and pronated feet, boys in the abnormal category have a visibly higher percentage body fat (medium effect, d≈0.5) than normal ones. Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between percentage body fat and the prevalence of winged scapulae ($r_s \approx 0.3$) and protruding abdomen ($r_s \approx 0.3$). Boys with a higher percentage body fat showed a significantly higher prevalence rate for protruding abdomen, where boys with a lower percentage body fat showed a significantly higher prevalence rate for winged scapulae.

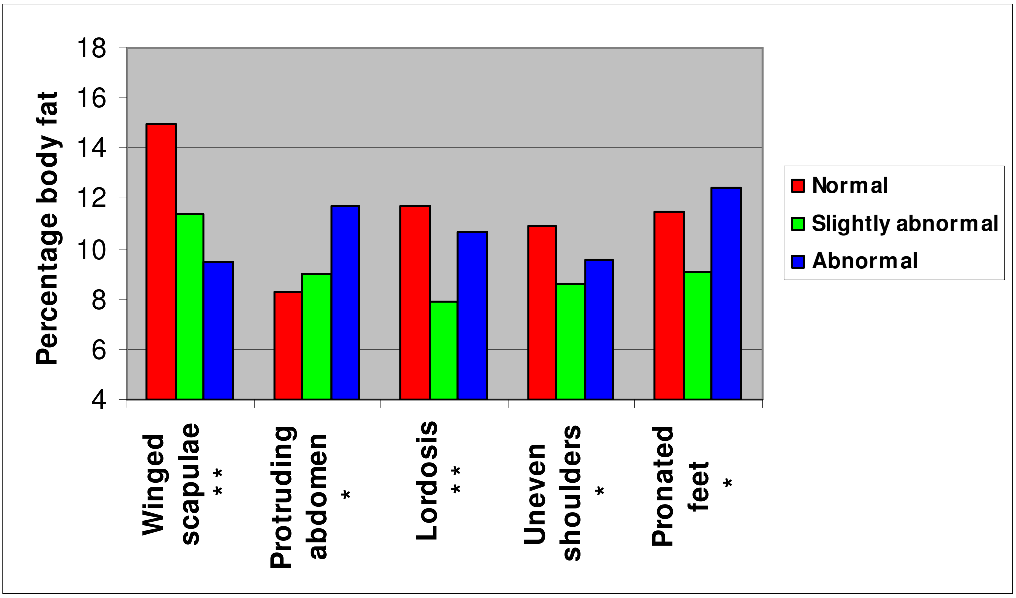

FIGURE 3: **THE EFFECT OF PERCENTAGE BODY FAT ON THE PREVALENCE RATE OF POSTURAL DEFORMITIES IN 11 TO 13 YEAR OLD BLACK SOUTH AFRICAN BOYS (* * LARGE AND * MEDIUM PRACTICAL SIGNIFICANCE) (N=79)**

For winged scapulae, girls in the abnormal category (figure 4) have a visibly lower percentage body fat (medium effect, $d \approx 0.5$) than normal ones. Girls with abnormal flat feet demonstrated to have in practice a higher percentage body fat (large effect, $d \approx 0.8$) than those who are normal. For protruding abdomen and pronated feet, girls in the abnormal category have a visibly higher percentage body fat (medium effect, $d \approx 0.5$) than normal ones. Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between percentage body fat and the prevalence of winged scapulae ($r_s \approx 0.3$), protruding abdomen ($r_s \approx 0.3$) and flat feet ($r_s \approx 0.3$). Girls with a higher percentage body fat showed a significantly higher prevalence rate for protruding abdomen and flat feet, where girls with a lower percentage body fat showed a significantly higher prevalence rate for winged scapulae.

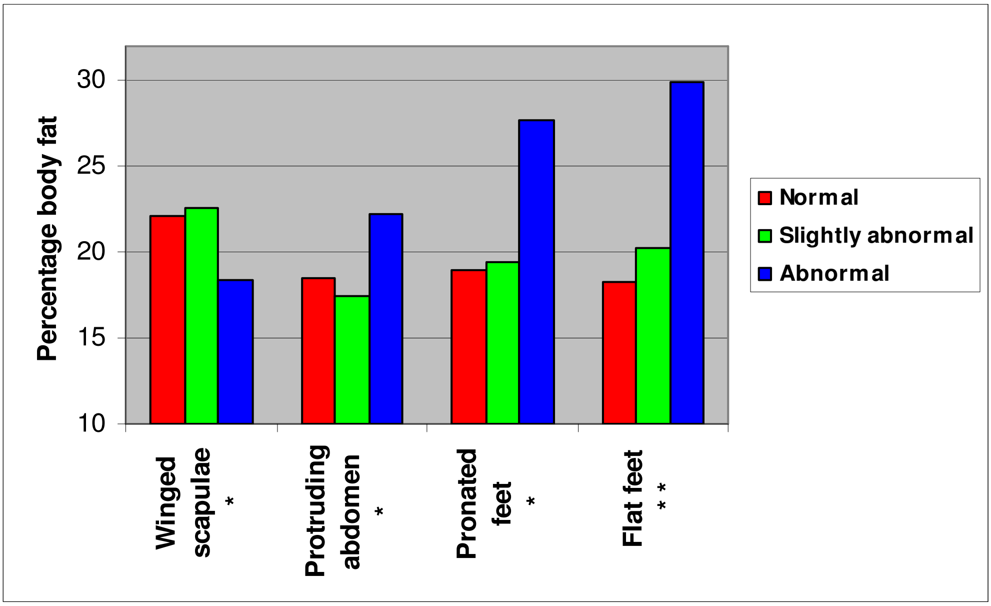

FIGURE 4: **THE EFFECT OF PERCENTAGE BODY FAT ON THE PREVALENCE RATE OF POSTURAL DEFORMITIES IN 11 TO 13 YEAR OLD BLACK SOUTH AFRICAN GIRLS (* * LARGE AND * MEDIUM PRACTICAL SIGNIFICANCE) (N=89)**

DISCUSSION

Research literature examining the possible association between postural deformities and body composition is lacking, especially with regards to black children.

Górniak and Poplawska (2004) evaluated Polish rural girls age 7 to 19 years and found girls with a good body posture to be heavier and have a higher percentage body fat, than those with a postural deformity. This is in accordance with the present study's findings in that girls with a higher percentage body fat and BMI had a lower prevalence rate for winged scapulae.

Cheung (2003) found BMI of adolescents with scoliosis to be significantly lower than the control group with no spinal deformity. This finding could not be confirmed in the present study, where no significant association was found between BMI and scoliosis. This is in accordance with a study by Grivas *et al.* (2002) who found no statistical difference between the BMI of children with scoliosis and their nonscoliotic counterparts.

In accordance with the present study's findings Bordin *et al.* (2001) found a high percentage of children with flat feet to have a higher BMI and percentage body fat. Riddiford-Harland *et al.* (2000) concluded that body mass had a significant effect on the foot structure of children. This may be due to the increased stress placed on the feet by the need to bear excessive weight. A recent study by Irving *et al.* (2007) concluded that a high BMI is associated with pronated foot posture and chronic plantar heel pain.

The present study's findings demonstrated a significant association between percentage body fat, BMI and the prevalence of protruding abdomen, flat feet and pronated feet, where children with a higher percentage body fat and BMI showed a significant higher prevalence rate for these deformities. These findings are supported by the literature (Post *et al.*, 1999; Riddiford-Harland *et al.*, 2000; Bordin *et al.*, 2001; Irving *et al.*, 2007).

It is clear that boys with a high prevalence rate for winged scapulae, lordosis and uneven shoulders demonstrated a lower BMI and percentage body fat, where girls with a high prevalence rate for winged scapulae demonstrated a lower BMI and percentage body fat. In contrast with the present study's findings Tüzün *et al.* (1999) and Murrie *et al.* (2003) found lumbar lordosis to increase with an increase in BMI. However, Stroebel (2002) found a higher prevalence rate for winged scapulae and lordosis in children with a lower BMI and percentage body fat. According to Banfield (2000), poor nutrition can lead to sagging posture, round shoulders and poor muscle tone. Poor muscle tone, especially in the serratus anterior or trapezius muscles can cause winged scapulae (Shultz *et al.*, 2005). Also, an increase in the prevalence for winged scapulae in leaner subjects, as in the present study, may be explained by the fact that this deformity is more easily identified in leaner children.

Although the present study reported an association between body composition and prevalence of postural deformities, it is important to note that in girls, only flat feet demonstrated a large practical significance with regards to BMI and percentage body fat. In boys, only winged scapulae and lordosis demonstrated a large practical significance with regards to BMI and percentage body fat. However, care must be taken in interpreting the results of the present study as the majority of children in this study were underweight or of normal weight and thus, associations might not have been observed because of the restricted range of the body composition data. Therefore, it is questionable whether the results of this study are appropriate to compare to studies in developed countries. A follow up study investigating black children that are more westernized and overweight, may give a more accurate indication of the association between body composition and the prevalence of postural deformities.

CONCLUSION

In summary the findings suggest that winged scapulae and lordosis in boys and flat feet in girls are the postural deformities with the strongest association with BMI and percentage body fat.

If a clear association can be established between body composition and postural deformities, screening can be implemented in schools to identify those children at risk for developing problematic postural deformities. In the researchers' opinion this study illustrates the need for further investigation of more profound studies investigating factors such as BMI and percentage body fat.

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